Lethal and sublethal synergistic effects of a new systemic pesticide, flupyradifurone (Sivanto™) on honey bees

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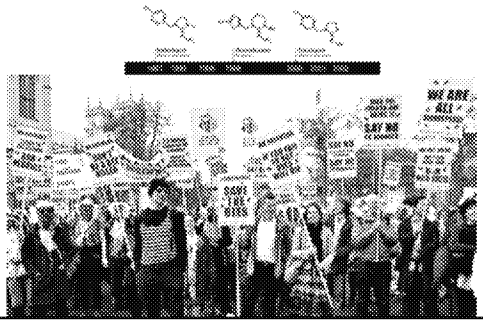
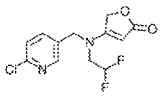
Growing resistance to neonicotinoids



Resistance & gov. regulation → flupyradifurone

- Modeled after natural product stemofoline (Nauen et al. 2015)
- Effective against insects resistant to neonicotinoids (Nauen et al. 2015)
- Favorable honey bee safety (BayerCrop Science 2013, Campbell et al. 2016)



Flupyradifurone

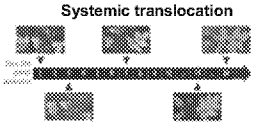
Acute oral toxicity LD50	3.2 µg active ingredient/honey bee
Acute contact toxicity LD50	15.7 µg a.i./honey bee
Field studies (active foraging)	No adverse effects up to 200 g a.i./ha

Flupyradifurone: a new nicotinic acetylcholine receptor agonist

Mode of action

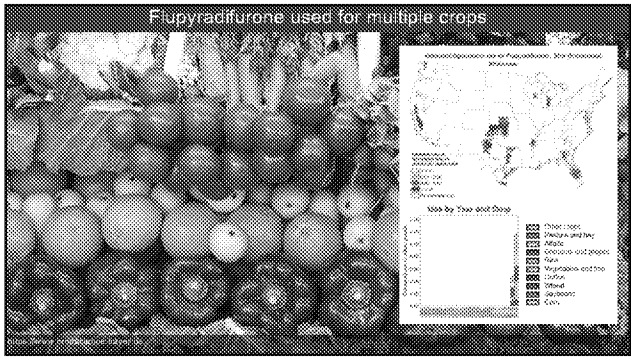
Widely used

Systemic translocation

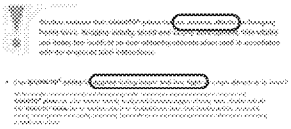


Bayer CropScience, IRAC

Flupyradifurone used for multiple crops



Bee safe?



No significant effects in field tests: colony mass, eggs, workers, etc. (Campbell et al. 2016)

Reduces Asian honey bee (*A. cerana*) learning at high field-realistic levels (196 ng/bee, Tan et al. 2017)

Reduces *A. mellifera* sucrose responsiveness, decreases olfactory learning, & disrupts motor coordination at high (field realistic?) levels (1200 ng/bee, Hesselbach & Scheiner 2018, 2019)

Doses & concentrations

Foragers collecting nectar in a field previously sprayed with FPF can be exposed to
- 1564 ng FPF/bee/foraging flight (cotton)
- 5504 ng FPF/bee/foraging day

Refined Estimated Environmental Concentration (EEC) of FPF (EPA 2014):
- **970 ng/bee for nurses (oilseed rape)**
- **1256 ng/bee for foragers (oilseed rape).**
- **6370 ng/bee for foragers (cotton)**

Synergy?

Fungicide = Propiconazole (PRO). SBI fungicide used on similar crops. PRO concentration (700 ppm) used in other studies and does not harm bees (Sgolastra et al. 2017, Thompson et al. 2014).

FPF and PRO should not be tank mixed (labelled), but could be separately used on the same/adjacent crops and can be found together in bee-collected pollen (Tosi et al. 2018)

Flupyradifurone (FPF) + Propiconazole (PRO)

DOSES	CONCENTRATIONS
0 ng/bee	0 ppm
750 + 7000 ng/bee	75 + 700 ppm
1500 + 7000 ng/bee	150 + 700 ppm
3000 + 7000 ng/bee	300 + 700 ppm
6000 + 7000 ng/bee	600 + 700 ppm

REFERENCES
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Experimental Design

- Treatments (blind)
  - **Flupyradifurone** (5 levels)
  - **Propiconazole** (1 level)
  - **PRO & FLP** (synergy test)
- Measurements (Standard Ecotox procedures)
  - Survival
  - Abnormal behaviors

Abnormal behaviors

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[illegible]	[illegible]
[illegible]	[illegible]
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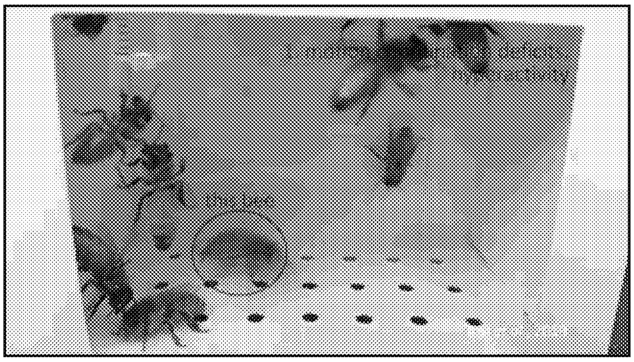
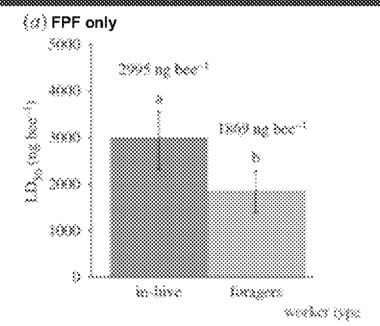
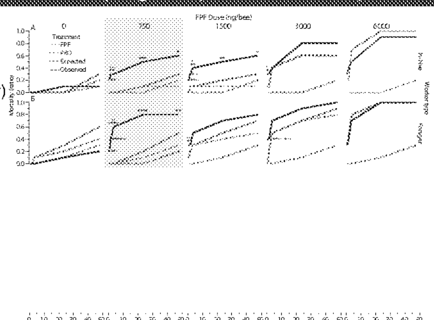


FPF + PRO toxicity changes with bee age/task



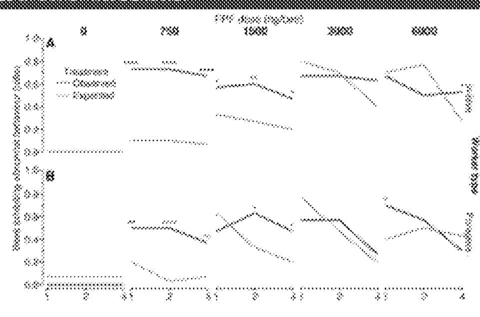
Worst-case field-realistic dose synergistically increased mortality

Treatment (synergy)



Tosi & Nieh 2019

Increases in abnormal behavior



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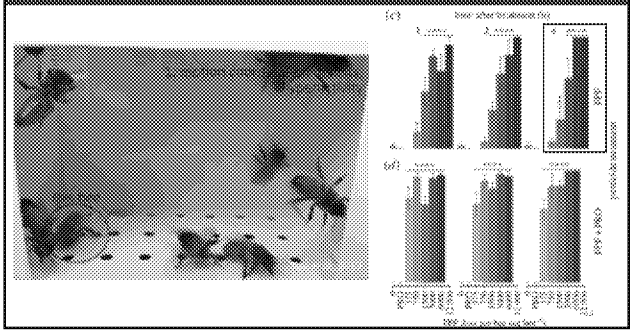
Increases in abnormal behavior



Conclusions

Flupyradifurone

1) More toxic in summer than spring*.
1) More toxic to foragers than in-hive bees*.
1) Synergistic effects with fungicide (propiconazole)*.
4) Increased trembling, rolling, jumping, falling, and erratic movements*.

*Similar to the effects of others pesticides (neonicotinoids)

Recommendations

1) Further study warranted, particularly conjunction of FPF and other bee stressors.
2) Refine RA to include assessment of abnormal behaviours
3) Refine RA to include tests of synergy with commonly encountered pesticides
4) Evaluation of FPF levels in crops and in colonies needed as FPF becomes more widely used.

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